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THESIS

**NONPARAMETRIC COST EVALUATION OF THE
DEPARTMENT OF DEFENSE'S SMALL PARCEL
SHIPPING PROCEDURES**

by

Douglas M. Murphy

September, 1995

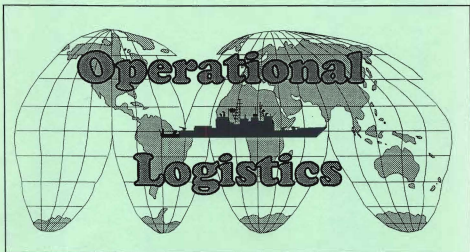
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Form Approved OMB No. 0704-0188

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1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE September 1995	3. REPORT TYPE AND DATES COVERED Master's Thesis	
4. TITLE AND SUBTITLE NONPARAMETRIC COST EVALUATION OF THE DEPARTMENT OF DEFENSE'S SMALL PARCEL SHIPPING PROCEDURES		5. FUNDING NUMBERS	
6. AUTHOR(S) Douglas M. Murphy		8. PERFORMING ORGANIZATION REPORT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey CA 93943-5000		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited.		12b. DISTRIBUTION CODE	
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14. SUBJECT TERMS Small Parcel Shipping, SSPA, Logistics, Nonparametric Data Analysis		15. NUMBER OF PAGES 84**	
		16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18 298-102

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**NONPARAMETRIC COST EVALUATION OF THE DEPARTMENT OF
DEFENSE'S SMALL PARCEL SHIPPING PROCEDURES**

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN OPERATIONS RESEARCH


from the


**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

The current Department of Defense shipping procedures do not encourage Installation Transportation Officers (ITOs) to use small parcel carriers (SPCs) for domestic ground transportation. There is still a significant amount of small parcels being shipped by the more expensive common carriers used for large Truckload and Less-Than-Truckload freight. The first purpose of this thesis is to show small parcels can be shipped more efficiently by SPCs than common carriers. The second purpose is to predict the optimal breakpoint weights that will bolster the greatest reduction in shipping cost. The results can be applied to current procedures to encourage the ITOs to best employ the SPCs. Nonparametric data analysis techniques are used to test hypotheses made about the data for fiscal year 1994. The first test shows potentially 3.1 million dollars can be saved annually using United Parcel Service (UPS) for all qualified parcels. The second series of tests bounds the optimal breakpoint weight for Over-The-Counter UPS rates and discounted UPS rates. By using the intersection of two lines of regression, the resulting breakpoints were 116 and 130 pounds, respectively. The second tests show potentially 3.4 to 3.8 million dollars can be saved annually using UPS for the above breakpoint strategies.

EXECUTIVE SUMMARY

The Department of Defense (DOD) uses commercial common carriers to transport domestic shipments by ground. A complex process used to hire carriers has developed throughout history. It is dependent upon a multitude of variables controlled by individual Installation Transportation Officers (ITO). The ITO classifies shipments by size, commodity, and special handling procedures. He must determine if the parcel is required to travel by any prearranged traffic agreement, Guaranteed Traffic Program (GTP). Then, with the assistance of Military Traffic Management Command (MTMC), the ITO hires the lowest cost available carrier, taking the above information into account without forgetting numerous other rules involving governmental contracts. To further complicate the matter, shipping rates vary greatly among the thousands of common carriers with no particular structure since they all tend to specialize in specific geographical regions or commodities. The process is difficult to comprehend, yet greatly effective for DOD Traffic Management.

The DOD is looking toward small parcel carriers to further reduce shipping costs of parcels that weigh 150 pounds or less. The proposed Surface Small Package Agreement (SSPA) will be tested by MTMC on a limited number of large Defense Logistics Agency (DLA) depots to determine feasibility. The SSPA will guarantee companies such as United Parcel Service (UPS) all small parcel traffic originating from the named DLA depots in return for discounted guaranteed rates. However, additional savings may be realized by encouraging ITOs to use the small parcel carriers (SPCs) as a regular procedure. Preliminary analysis performed by MTMC has predicted a savings of

28%, i.e. 2.6 million dollars based on FY 1993 data, on current shipping costs by employing UPS for all DOD parcels that weigh 150 pounds or less.

The actual shipping costs paid by the government for parcels 150 pounds or less varies dramatically due to the same reasons discussed above, but tend to congregate near 35 to 40 dollars per shipment. This is due to the fact that small parcels are not efficiently transported by common carriers, since the common carriers are inclined to tailor their business to much larger freight. The majority of their rates come from minimum shipping charges created to compensate for the inefficiencies of delivering small parcels. In general, as long as small parcel carrier rates are below 35 to 40 dollars per package, their use will save the DOD shipping costs. However, SPC shipping rates do exceed 35 dollars and this implies it is not optimal to employ them to deliver all parcels 150 pounds or less. There must exist a breakpoint weight at which the strategy should change from SPCs to common carriers.

The first problem of this thesis is to show that MTMC results are valid and may be backed statistically. The second problem of this thesis is to identify the breakpoint weight at which it is no longer advantageous to use SPCs to transport small parcels. The resulting breakpoint weight will provide valuable information to develop strategy for the employment of SPCs for both O-T-C and discounted SSPA rates.

This thesis uses nonparametric data analyses to solve the above stated problems because the actual costs data does not have an easily identifiable distribution and contains an undetermined number of descriptive parameters. Additionally, for the second problem,

the shipments were divided into 15 separate weight classes and then tested individually. Each test will show only which carrier is better for each weight class, but will bound the optimal breakpoint weight by the classes where the strategy changes. Once the optimal breakpoint weight is bounded a normal distribution assumption is used within the bounds to predict the breakpoint weight by the intersection of two lines of regression.

The Wilcoxon Signed-Rank Test shows that small parcel carriers are the least expensive mode of transportation for small parcels. They provide a savings of 34% of present shipping costs, potentially saving 3.1 million dollars annually if fully employed. The Wilcoxon Signed-Rank Test bounded the optimal breakpoint weight between 91 and 120 pounds for O-T-C rates and 101 to 130 pounds for discounted SSPA rates. The intersection of two lines of regression predicts the breakpoint weight to be 116 pounds for O-T-C rates and 130 pounds for SSPA discounted rates. The savings increases to 48% (potentially saving 3.4 to 3.8 million dollars annually) of present shipping costs if both O-T-C and SSPA users tailor their shipping procedures to accommodate the optimal weights. This thesis is performed at a macro level targeting all DOD installations. Further studies should concentrate on individual installations and their specific shipping procedures to better reduce costs in the future.

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LIST OF ACRONYMS

The following acronyms are used frequently in the thesis and are listed below for the reader's reference:

CFM	Consolidated Freight Management
CONUS	Continental United States
CPP	Carrier Performance Program
DLA	Defense Logistics Agency
DOD	Department of Defense
FAK	Freight All Kinds
FINS	Freight Information System
FY	Fiscal Year
GTP	Guaranteed Traffic Program
ITO	Installation Transportation Officer
LTL	Less-Than-Truckload
MOT	Method of Transportation
MTMC	Military Traffic Management Command
NMFC	National Motor Freight Commodity
O-T-C	Over-The-Counter
RPS	Roadway Package System
SPC	Small Parcel Carriers
SRO	Standing Route Order
SSPA	Surface Small Package Agreement
TL	Truckload
UPS	United Parcel Service
USPS	United States Postal Service

I. INTRODUCTION

Since the end of the Cold War, the defense budget has rapidly become smaller. Virtually all facets of the Department of Defense (DOD) are operating with less funds, requiring everyone to seriously cut all unnecessary spending. The DOD transportation section is not immune to budgetary constraints and has implemented numerous new policy changes to further reduce operating costs. One consideration for reducing costs is to further reduce shipping costs by seeking lower rates for DOD traffic. The deregulation of the transportation industry has encouraged the growth of carriers that specialize in the shipment of small parcels. Their rates are very appealing for those shipments that weigh less than 150 pounds, and are extensively used by civilian industries.

Current DOD policy does not encourage Installation Transportation Officers (ITOs) to take advantage of these specialized rates. Military Traffic Management Command (MTMC) requires ITOs to use the lowest cost carrier, but simultaneously tells them to use the Guaranteed Traffic Program (GTP) whenever possible, and this sends a mixed signal. The result is that small parcels are shipped by both common and small parcel carriers (SPCs). [Ref. 1] Since common carrier rates are tailored for much larger shipments, the cost for shipping a parcel of less than 150 pounds can be as much as ten times the cost of using a specialized carrier. Conversely, some common carriers do offer competitive rates that may be lower than their small parcel counterparts. Many ITOs process hundreds of parcels a day and due to the complexity of the rate system, do not verify which carrier has the lowest rates in all cases.

MTMC is planning on implementing a program similar to GTP called the Surface Small Package Agreement (SSPA) by 1996 [Ref. 1]. SSPA should alleviate the problem with "mixed signals" and require those ITOs with high volume small parcel traffic to utilize the SPCs. MTMC is projecting a potential savings of 28% to 52%, based upon Fiscal Year (FY) 93 data [Ref. 2]. SSPA should save the DOD millions of dollars in shipping costs, but may not optimize the potential savings if SPCs are utilized when common carriers are less expensive. It may not be optimal to have SSPA incorporate the entire range of weights that the SPCs will ship. For example, if DOD saves 4 million dollars by using SPCs for parcel weights of 1 to 100 pounds and over spends 1 million dollars for parcel weights of 101 to 150 pounds, then it is better to only use SPCs for weights up to 100 pounds where they are more affordable.

It is vital to have a minimum amount of information on historical and current shipping procedures to comprehend the complexity of DOD traffic management. Chapter II. presents a historical perspective on the events that have come to shape DOD's current method of traffic management. Chapter III. presents basic shipping terms, current procedures, and proposed programs for individuals not familiar with the DOD transportation business. Both chapters are for the reader's information and may be utilized at his/her discretion.

II. HISTORICAL PERSPECTIVE

A. PRE-DEREGULATION

Regulation of the transportation industry began and was emphasized by Congress in the Declaration of National Transportation Policy in the Transportation Act of 1940. The idea was for the federal government to direct transportation policy to best "...meet the needs of the commerce of the United States, of the Postal Service, and of the national defense". Additionally, they wanted to "...*promote* safe, adequate, economic and efficient service and *foster sound economic conditions* in transportation and among the several carriers". [Ref. 3]

The DOD land transportation is administered by MTMC. MTMC is responsible for the review and maintenance of the standard tenders-of-service (tenders) submitted by carriers that wish to provide transportation services to the DOD. Tenders provide the government with the precise rates and services the carrier is willing to supply for a specific shipping route. The tenders are used by MTMC to identify the low cost carrier that would be offered the proposed shipment. If the shipment is not accepted by the low cost carrier, the next low cost carrier is offered the shipment.

Prior to the deregulation of transportation there were relatively few carriers that submitted tenders to MTMC for consideration. The delegation of shipments was spread easily among well established reliable carriers with well regulated government rates. When a shipment needs to be transported from one DOD installation to another, the ITO

initiates actions and coordinates with MTMC to hire the carrier to perform the movement. The majority of time required to hire a carrier was spent by MTMC researching the tenders for the lowest cost. A Standing Route Order (SRO) is a document that was developed to reduce research time by listing carriers for a particular route in order of ascending cost. An SRO may be established for any route with a relatively high traffic density. It is reviewed and updated every 30 days by MTMC to ensure accuracy, allowing an ITO to instantly obtain the low cost carrier for the route of interest.

In the early 1960s, movement toward deregulation swept through the transportation industry due to a desire to allow more competition. President John F. Kennedy in 1962 addressed this desire in his transportation message that stated:

... a chaotic patch work of inconsistent and often obsolete legislation and regulation has evolved. ...transportation is subject to excessive, cumbersome, and time-consuming regulatory supervision that shackles and distorts managerial initiative. ...greater reliance on the forces of competition and less reliance on the restraints of regulation (is called for).

In the 1970s, the consumerism movement and the high cost of regulation encouraged the drift toward deregulation of the transportation industry. Real deregulation began with the Airline Deregulation Act of 1978. It continued with the Motor Carrier Act of 1980 and the Staggers Rail Act of 1980 that removed many of the old rules and regulations that controlled the industry. [Ref. 3]

B. POST-DEREGULATION

Deregulation accomplished three major things. It made it easier for new carriers to enter the market and provide more competition. It permitted a more flexible pricing structure that allowed carriers to offer discounted rates, and it relaxed many of the cumbersome regulatory rules. The impact of deregulation of motor transportation was seen almost immediately. The number of motor carriers increased by 63% in the first three years of deregulation and more than doubled within ten years after deregulation. Additionally, carriers started to offer discounted rates on particular routes for which they were interested in specializing. ITOs began to take advantage of these discount rates and in many instances entered contracts with the carriers that could provide them with the guaranteed rates and services they desired. [Ref. 3]

The sudden insurgence of carriers into the market dramatically increased the number of tenders submitted to MTMC for DOD traffic. The amount of time it took MTMC to research the lowest cost carrier was immense and caused a considerable increase in ITO service times. SROs became more attractive to the ITO by avoiding the enormous research times involved for each shipment. The ITOs requested MTMC to establish SROs along high volume routes utilized by their commands. The SROs substantially reduced the delay time caused by research, but markedly increased MTMC work load managing the SROs. The 30 day review cycles required to maintain SRO accuracy began to fall behind schedule. In order for the SROs to continue to provide the

low cost carrier, MTMC would have to either bolster its manpower or find a new way to make use of a more competitive and larger motor carrier industry. [Ref. 4]

MTMC began to experiment with contract carriers like their civilian counterparts, and eventually created the GTP. GTP allowed MTMC to contract a carrier to handle all traffic on a particular route and receive guaranteed rates. Unlike the 30 day review requirement of SROs, a GTP agreement could be as long as three years providing guaranteed rates. Similar to SROs, GTP could only be used on essentially high-volume traffic routes from a single origin to a single or multiple named destination. GTP reduced operation costs for MTMC while providing low rates that stemmed from a highly competitive bidding process. Since its birth, the GTP has proven to be a very efficient way for the DOD to conduct its motor traffic management for those shipments and routes that qualify. [Ref. 4]

All traffic that could not be moved under the GTP continued to be processed using SROs or researching the tenders as in the past. To better control this process, MTMC has computerized the SRO and tender data bases. The data bases are essential to the Consolidated Freight Management (CFM) system which will automate the tender research operation and make the SRO review program much easier. In conjunction with GTP, the CFM system should rectified the manpower problems that have plagued MTMC since the deregulation of the transportation industry.

III. BACKGROUND

A. DELEGATION OF TRAFFIC MANAGEMENT

DOD domestic traffic management is a highly complicated business that is the primary responsibility of MTMC. MTMC has the authority to delegate some of the work and responsibilities to the command ITOs. The amount of work involved is dependent on the elements of the shipment: (1) National Motor Freight Commodity (NMFC), (2) movement type, and (3) special shipping requirements. If the proper combination of the above elements is achieved then the ITOs have the authority to move their shipments with the low cost carriers with little to no consultation with MTMC. [Ref. 4]

1. National Motor Freight Commodity (NMFC)

Shipments are divided into various commodity categories that separate them into everything from household goods to several classes of explosives. Each category has it's own shipping requirements. Some categories require specialized vehicles for transportation, while others may call for any number of security precautions to ensure shipment integrity. Approximately 90% of all DOD shipments are of commodity category Freight All Kinds (FAK). Such general freight as spare/repair parts, lumber, toilet paper, etc. are categorized as FAK. FAK is basically anything but explosives, household goods, live animals, and a few other things. FAK allows an ITO the most flexibility of all

commodity categories in booking his/her own shipment with minimal interaction with MTMC.

2. Movement Type

Movement types refer to whether or not the shipment qualifies for the GTP. If the shipment qualifies to be moved in accordance with the GTP, the ITO may book the shipment in accordance with the rules that govern the GTP. Otherwise, the ITO may require assistance from MTMC. If the shipment involves any special handling procedures; does not fall under an authorized SRO; or requires additional research to find the low cost carrier is required, then MTMC must be consulted prior to booking a carrier.

3. Special Handling Requirements

Special handling requirements may be required in a couple of different situations, the most common of which is the NMFC category discussed above. Other reasons may involve security requirements depending upon whether or not the shipment is classified, or the shipment priority which may affect the speed at which the shipment must be delivered. Unless otherwise directed, special handling requirements will always involve MTMC intervention.

B. ADDITIONAL ELEMENTS OF A SHIPMENT

There are additional elements of a shipment that are important to the decision process that determines what carrier is chosen to move a particular shipment.

1. Origin/Destination

The origin is the location from which the shipment is being moved, and the destination is the location to which the shipment is being moved. A particular origin/destination pair may also be referred to as a route. The route is important in determining which carriers are eligible to service a particular shipment. If the shipment is qualified to move under the GTP, then a primary carrier and two alternate carriers are provided to the ITO depending on the size of the shipment. If the route has an SRO, then several carriers in order of lowest cost depending on shipment size are provided by the SRO. In all other cases either the ITO or a MTMC agent will use the route within the CFM system to initiate the tender research process.

2. Method of Transportation (MOT)

There are several different MOTs for domestic motor transportation. The specific type used for a particular shipment is determined by the ITO requesting the transportation. There are approximately 150 MOT codes that describe the specific MOT requested. These codes identify the type and size of the MOT, and any specialized characteristics such as refrigeration or load capacities.

3. Size Category

There are only two size categories, Truckload (TL) and Less-Than-Truckload (LTL). Generally a TL movement refers to a shipment size of 15,000 pounds or more, and utilizes most of the useable volume of a truck. An LTL movement is anything 14,999 pounds or less, and does not fully utilize the volume of the truck. For that reason LTL shipping rates are generally higher than TL shipping rates. In order to choose a carrier, the ITO must know his/her shipment size to determine the lowest rate available. [Ref. 5]

C. GUARANTEED TRAFFIC PROGRAM (GTP)

The GTP has become the cornerstone for DOD domestic traffic management. The program was developed to reduce both operating and administrative cost while enhancing ITO service. The GTP is a conglomeration of agreements that guarantee a variety of carrier services and rates to an ITO, and guarantees all traffic on a specific route to a named carrier. The agreements do not guarantee a specified amount of traffic or dollar value of business.

1. Types of Agreements

The GTP consists of two major types of agreements, motor/rail and air. For the purpose of this thesis, only the motor/rail agreements are relative. The motor/rail agreements provide three types of services: (1) Dedicated Service - carrier provides

dedicated equipment to fulfill a service requirement; (2) Scheduled Point-to-Point Service - carrier provides service from single named origin to multiple named destinations; and (3) Scheduled Geographical Region Service, which is the same as point-to-point services, except destinations are named as a group of states. [Ref. 4]

2. Solicitation and Award Process

ITOs are required to determine if any of their traffic qualifies under the terms for consideration of the GTP. The GTP must be considered for any route that meets at least one of the following criteria: (1) volume over 1 million pounds annually, (2) repetitive traffic, (3) special services required, (4) involve large exercises, (5) potential administrative savings, or (6) specific ITO requests. If the ITO feels any of his/her routes qualifies for the GTP, he submits a draft letter of solicitation to MTMC for consideration. The draft letter contains the actual agreement requirements, including type of service discussed earlier, potential traffic volume estimations, and other elements necessary for creating an agreement. [Ref. 6]

Upon approval by MTMC, formal letters of solicitation are submitted to all qualified DOD carriers. The solicitations may be divided into eleven destination regions, and TL and LTL shipment sizes. The carriers are invited to submit their bids by a designated date. All bids are considered in terms of service, cost, fuel consumption, and equitable distribution. MTMC names a primary and two alternate carriers for each agreement awarded. [Ref. 6]

3. Administering the Program

The ITOs are responsible for administering their respective GTP agreements, and ensuring the carriers provide appropriate service in accordance with the Carrier Performance Program (CPP). The ITOs must utilize the primary carrier for all shipments that fall under the terms of a specific GTP agreement, unless the primary carrier turns down the shipment requiring a named alternate carrier to be used. When carrier performance does not meet the guidelines of the CPP, ITOs submit files on carrier performance to MTMC for agreement termination. MTMC will determine appropriate action which may consist of agreement termination or loss of DOD carrier qualification if service does not improve. [Ref. 5]

D. SMALL PARCEL CARRIERS (SPCs)

SPCs historically have not been used for the shipment of DOD small parcel freight. Prior to the emergence of SPCs, all freight traveled by common carrier and in many instances still does today. Civilian companies quickly took advantage of the specialized rates, and have produced a multi-billion dollar market for the SPCs. There are hundreds of carriers that claim to provide the specialized service, but in ground service there are only two major players, United Parcel Service (UPS) and Roadway Package System (RPS). [Ref. 2]

1. United Parcel Service (UPS)

UPS provides full service to the 48 contiguous states and the District of Columbia. They are headquartered in Atlanta, Georgia and grossed approximately 17.78 billion dollars in 1993. [Ref. 2] They provide similar types of services defined in the GTP, highlighted by state-of-the-art parcel tracking capability. UPS prides itself on being a paperless company. Their contracting, billing, and payment procedures are predominately done electronically, and resist involving large clients that do not have that capability. [Ref. 1]

2. Roadway Package System (RPS)

RPS is UPS's biggest competitor in ground transportation and has relatively the same services, but only provides them to 33 contiguous states and the District of Columbia. RPS plans to service all 48 contiguous states by 1996. They are headquartered in Pittsburgh, Pennsylvania, and grossed over one billion dollars in 1993. [Ref. 2] RPS is also paperless and encourages the same from their clients [Ref. 1].

3. SPC "Over-The-Counter" Rate Determination

Over-The-Counter (O-T-C) rates refer to those rates offered to a customer with no special rate agreement in place with the carrier. Both UPS and RPS use the United States Postal Service (USPS) zip code system to define the distance component of their O-T-C rate structure. Rates are determined by looking up the zone that defines the route,

and then applying the appropriate rate. For ground transportation, there are eight zones defined roughly as eight range rings that extend out from the originating point (see Table 1). A zone is found in a table designed with respect to the first three digits of the zip code for the originating point, and is listed for the first three digits of the zip code for the destination point. The rate that is applied comes from the effective rate chart by entering the weight and zone for the shipment. [Ref. 2]

Zone	Mileage Band
1	0-50
2	51-150
3	151-300
4	301-600
5	601-1000
6	1001-1400
7	1401-1800
8	1801- and up

Table 1. Zone Mileage Bands From Ref. [2]

E. SURFACE SMALL PACKAGE AGREEMENT (SSPA)

SSPA is a program to be structured similar to that of the GTP, with a goal to provide contracted SPCs to carry all qualified DOD small parcels. Studies by the Traffic Management Analysis Division of MTMC concluded SSPA would be cost beneficial if pursued. The exact terms of the solicitation and prospective agreements are still under consideration, but it is speculated the SPCs will provide at least a ten percent discount to

current O-T-C rates. SSPA is to consist of agreements that provide the same three types of services as GTP. The first solicitations will be for the large Defense Logistics Agency (DLA) depots, and offer service for all traffic less than 150 pounds that meets parcel dimension restrictions. Current goals are to present formal solicitations from MTMC to all interested SPCs, and evaluate bids by early 1996. [Ref. 1]

F. CURRENT METHOD OF SMALL PARCEL SHIPPING

Below is a diagram (Figure 1.) that represents the flow of decisions an ITO would make in order to choose the lowest cost carrier. He must first consider if the prospective shipment falls under the GTP, and if it does then the shipment is booked accordingly. Otherwise, the shipment is booked using the appropriate SRO, or researching the tender data base through the CFM system. Under current guidelines an ITO is not required to check the SPC rates to see if they are lower. They are only indirectly encouraged to do so through their commitment to use the lowest cost carrier available.

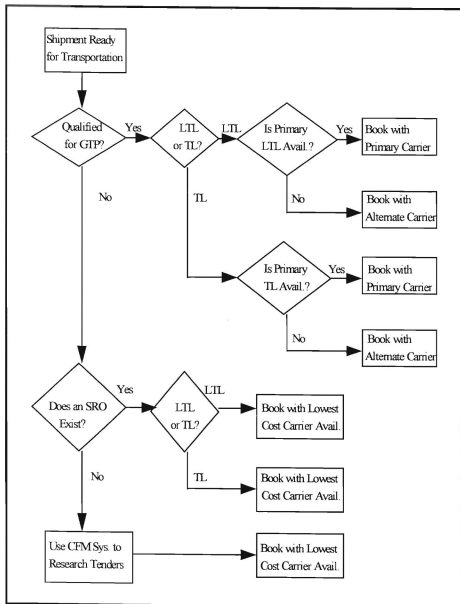


Figure 1. Shipment Decision Flow Diagram

IV. PROBLEM STATEMENT

A. ADVANTAGES OF SPCs

There are two reasons consideration should be given to SPCs when choosing the lowest cost carrier.

1. Minimum Charge

Common carriers bill a minimum charge to the ITOs. The minimum charge is a flat cost the majority of the time, or is a cost charged to a minimum weight (normally 200 pounds) at the appropriate LTL shipping rate. No matter what the actual size of the shipment, a constant cost is incurred depending upon which carrier is selected. This could be a very inefficient way to send small parcels. It is easily seen that a typical minimum charge of 40 dollars is significantly larger than a UPS rate of around four dollars for a one pound parcel. Additionally, that minimum charge of 40 dollars is constant over the weight range of SPCs, but the four dollar UPS rate increases significantly with weight. The SPCs may not be as affordable as the common carriers at the upper bounds of their weight range, which would imply that the current system is better. Due to the enormous imbalance of the lower weight range prices, it is almost certain that SPCs overall would be less expensive to use for small parcels. Also, it is very likely that the optimal weight range for utilizing the SPCs is not 1 to 150 pounds, but something smaller and should be considered.

2. Common Carriers Not Designed for Small Parcel Delivery

Unlike the SPCs the common carriers are not structured to be a small parcel delivery company. Common carriers have designed their companies to deliver TL shipments as efficiently as possible. They make their living hauling large freight from loading dock to loading dock by operating a variety of equipment types to best support their customers' needs. Different common carriers may specialize in different types of cargoes and are able to provide reduced rates. Common carriers cannot efficiently deliver small parcels with the types of equipment and personnel they employ. Therefore, they cannot compete with the rates or customer services provided by the SPCs, and choose to tailor their rates to accommodate large shipments. The minimum charges discussed above are used to compensate for the carriers' implied extra costs due to their inefficiencies.

B. PROBLEM DEFINITION

1. Show SPCs Are More Affordable Than Common Carriers

Using FY 94 Freight Information System (FINS) inquiry data for MTMC Western Area show that the DOD could have reduced costs by fully employing a SPC to carry all shipments less than 150 pounds. A significance factor (α) equal to 0.05 is to be used to ensure the result is statistically acceptable.

2. Find the Optimal Weight Range for SPC Employment

For reasons stated earlier, it may not be most beneficial to employ SPCs over the entire weight range serviced. Use the same FY 94 data to locate the weight at which the common carrier is statistically more affordable, breakpoint weight, than the SPC O-T-C rates. Figure 2. below illustrates the theoretical breakpoint for a more cost effective strategy than a full employment of the SPCs for small parcel shipping. Conduct a similar analysis using proposed SPC discounted rates to recommend a weight range for future SSPAs that best reduces costs.

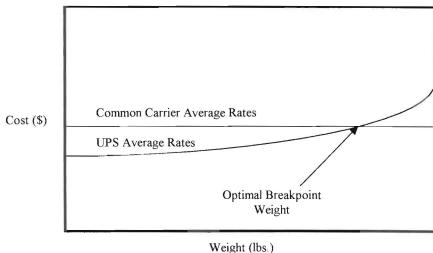


Figure 2. Theoretical Breakpoint

3. Provide Recommendations for System Integration

The SSPAs will only affect the large DLA depots initially, and may take years until fully inserted into the DOD transportation system. This thesis will recommend ways to encourage all ITOs to take advantage of potentially lower SPC rates, without completely disrupting the way business is conducted at their command.

C. ASSUMPTIONS

1. MOT/NMFC

Only shipments that list a van as its MOT and FAK as its NMFC will be considered during this analysis. It is assumed that any FAK being shipped in a van will qualify to be shipped by a SPC. No special handling procedures are necessary for FAK shipments and a SPC can provide identical transportation as a common carrier using a van.

2. Dimension Limitations

The analysis is testing whether a SPC's potential charges are less than those already accrued from common carriers over a shipment weight range. A common carrier charge for the weight range in question is a constant depending on the carrier and not the dimensions of the shipment. Since dimensions of the shipment are not available and not relevant to actual cost, then assuming SPCs are not limited by parcel dimensions should not have an effect on rate comparisons.

3. Transit Times

The difference in transit times for common carriers and SPCs is negligible and will not be considered important in this analysis. MTMC has already determined that SPC transit times and customer services are acceptable for DOD transportation needs. Once services are established with SPCs, then it may be appropriate to verify the validity of this assumption with actual transit times.

4. UPS Represents Rates and Services of a Typical SPC

UPS is the largest and provides the most complete geographical coverage of all SPCs for domestic ground transportation. As the leader of the domestic ground transportation market, UPS must provide competitive rates and services throughout all regions of the Continental United States (CONUS). Therefore, it is a reasonable assumption that the rates and services provided by UPS are typical and represent those SPCs that may also be interested in DOD small parcel delivery.

5. FY 94 Traffic Patterns are Approximated by FY 93

In order to apply UPS rates to parcels sent by common carrier, zone information must be determined by origin/destination USPS zip codes or mileage. Zip code information and route mileage are not available for the small parcels of concern in the data set to be used. MTMC Analysis Division using specialized computer software developed mileage data for parcels of similar weight and commodity for FY 93. The mileage data

was transformed into discrete zone information by applying the range bands discussed earlier, and produced a discrete zone distribution for FY 93. By assuming that the traffic patterns of FY 94 are approximate to those of FY 93, zones can be randomly applied to the FY 94 data using the discrete zone distribution illustrated in Figure 3. This assumption is reasonable and allows a stochastic approximation to provide additional realism of SPC rate information without changing the cost versus parcel weight distribution of the common carriers.

6. Discounted Rates for SSPA

The discounted rates offered for the SSPAs will be at least as good as ten percent off the O-T-C rates. UPS has historically reduced the O-T-C rates for contracted services and is expected to do the same for any agreement made with DOD. [Ref. 7]

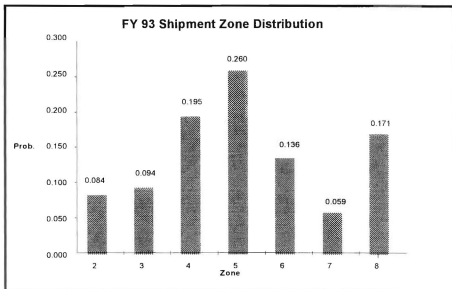


Figure 3. FY 93 Zone Distribution Developed From Ref. [2]

V. ANALYSIS

A. DATA COLLECTION

1. Freight Information System (FINS) Inquiry

The FINS Data Base Manager provided a FINS General Purpose Inquiry Report of Western Area routed FAK traffic, with weights from 1 to 150 pounds. The data was shipped as a compressed ASCII flat file on a three and a half inch computer floppy disk. This format provided an easy interface with Microsoft Excel where most of the analysis was computed. The General Purpose Inquiry provides all the information listed in Appendix A.

2. Data Preparation

Only those parcels delivered by van were considered in order to reduce the size of the data set to a value more conducive for evaluation (see Assumptions in Chapter III). There are 12,398 parcels in the data set to be analyzed, which is a good cross-section of those parcels that were qualified to use SPCs in FY 94. The data was divided into 15, 10 pound weight classes (see Table 2.) allowing for the evaluation of individual weight classes, to determine whether SPCs or common carriers were more cost effective.

Weight Class	Weight Range
1	1 - 10
2	11 - 20
3	21 - 30
4	31 - 40
5	41 - 50
6	51 - 60
7	61 - 70
8	71 - 80
9	81 - 90
10	91 - 100
11	101 - 110
12	111 - 120
13	121 - 130
14	131 - 140
15	141 - 150

Table 2. Weight Class Description

3. UPS Data

The UPS data set is produced by applying both the O-T-C and discounted UPS rates to every parcel shipped in the data set constructed above from the FINS inquiry. Using the UPS rate structure published for O-T-C application and a stochastically determined zone for a given parcel, a UPS O-T-C rate data set can be assembled. The ten percent discounted rate data is simply the result of reducing the UPS O-T-C rate data by

ten percent. Now, each common carrier charge has an associated UPS O-T-C and discounted rate that may be used as an alternative to the actual cost.

B. DEVELOPING A METHOD

To show that there is a statistical difference between two distributions, a number of parametric analyses are normally performed. The problem with using parametric analysis is there must be an assumption that there are a finite number of parameters describing the distribution. Due to the complicated method of determining the low cost common carrier, the number of actual parameters is not particularly sound. Therefore, an alternative way of analyzing the problem is necessary.

1. Nonparametric Analysis

Nonparametric analyses cover all instances where parametric analyses are not appropriate. Nonparametric analyses seem to be used for those observations not easily quantifiable or where an assumption of the original population distribution being normal is not suitable. Research has shown that nonparametric statistical tests have been known to be more capable of detecting population differences when critical parametric assumptions are not satisfied. Therefore, it would be more appropriate to use some type of nonparametric statistical test to show UPS rates are more affordable, since common carrier costs are not distributed normally over the range of parcel weights. [Ref. 8]

There are many different nonparametric statistical tests available to apply to the problem. Determining the appropriate test is a considerable exercise. A relatively easy way of determining whether UPS would be more affordable is to count the frequency of UPS being the cheaper carrier. If UPS is cheaper significantly more times than the common carriers, then it clearly follows that UPS is the cheaper carrier. Therefore, the real test statistic is whether the difference between the UPS rate and the common carrier rate is a positive or negative value.

2. Sign Test for a Paired Experiment

The Sign Test for a paired experiment is very similar to a paired-t test. A paired-t test tests whether the difference of two paired samples comes from the same population distribution by determining if the difference between the paired samples was zero. The paired-t test is a parametric test and uses the assumption that the samples come from a normal distribution. The Sign Test for a paired experiment only assumes that if the two samples come from identical distributions then the differences between the paired data will have approximately an equal number of positive and negative values. However, since the data is quantifiable, there is additional information available and a similar test may be more appropriate to use. [Ref. 8]

3. Wilcoxon Signed-Rank Test for a Paired Experiment

The Wilcoxon Signed-Rank Test goes one step further than the Sign Test by using the additional information provided by the magnitude of the difference. Not only should the difference between the paired data have approximately an equal number of positive and negative values, but the absolute magnitudes of the differences should occur with equal probability. This can be measured by ranking the absolute values of the differences and comparing the sum of the ranks of the positive and negative differences. If the samples are from the same distribution, then the two sums should be approximately equal. Therefore, the Wilcoxon Signed-Rank Test is the most appropriate test to determine which carrier is least expensive.

C. APPLYING THE METHOD

The Wilcoxon Signed-Rank Test will be applied to the data set in two different fashions in order to solve the first two problems stated in Chapter III. The first test will be to show that overall it is more beneficial to use UPS to ship small parcels than the common carriers. The second will be used to locate the breakpoint weight at which UPS is not as cheap as the continued use of the common carrier. The details for using the Wilcoxon Signed-Rank Test are given in reference 8.

1. Defining the Least Expensive Carrier Overall

In the report produced by MTMC Analysis Division in June of 1994, the conclusion showed that DOD FAK surface shipments could be moved by UPS at O-T-C rates for a 28.3 percent savings. The objective of the first portion of the analysis is to use a one-sided Wilcoxon Signed-Rank Test for a paired experiment with greater than 25 data points to prove that UPS will be the cheaper carrier based on the FY 94 data and assumptions. To do this, null (H_0) and alternative (H_a) hypotheses are made concerning the population relative frequency distributions.

H_0 : The population relative frequency distributions for UPS and common carriers charges are identical.

H_a : The population relative frequency distribution for the common carriers charges is shifted right of the relative frequency distribution of the UPS charges.

Rejection Region: $Z \geq z_\alpha$

The null hypothesis is that both the UPS and common carrier charges are the same and it is not more beneficial for the ITO to choose one over the other. The alternative hypothesis is that common carrier charges overall are higher than UPS charges and it would be more beneficial for the ITO to use UPS. Therefore, if the criteria for the rejection region is met, the null hypothesis is rejected and the alternative hypothesis is accepted.

2. Defining the Most Beneficial Weight Range for UPS

The objective of the second portion of the analysis is to use a one-sided Wilcoxon Signed-Rank Test for a paired experiment with greater than 25 data points to locate the weight classes at which UPS will be the cheaper carrier based on the FY 94 data and assumptions. To do this, null (H_0) and two alternative (H_a) hypotheses are made concerning the population relative frequency distributions.

H_0 : The population relative frequency distributions for UPS and common carriers charges are identical for weight class i .

H_a : 1) The population relative frequency distribution for the common carriers charges is shifted right of the relative frequency distribution of the UPS charges for weight class i .

2) The population relative frequency distribution for the common carriers charges is shifted left of the relative frequency distribution of the UPS charges for weight class i .

for all $i = 1$ to 15

Rejection Region: 1) $Z \geq z_\alpha$
2) $Z \leq -z_\alpha$

The null hypothesis is that both the UPS and common carrier charges are the same and it is not more beneficial for the ITO to choose one over the other. The alternative hypotheses are: 1) that common carrier charges overall are higher than UPS charges and it would be more beneficial for the ITO to use UPS and 2) that UPS charges overall are higher than common carrier charges and it would be more beneficial for the ITO to use a

common carrier. Therefore, if the criteria for the rejection region is met, the null hypothesis is rejected and the appropriate alternative hypothesis is accepted.

It is expected that alternative hypothesis 1) will be accepted from weight class 1 up to i and alternative hypothesis 2) will be accepted from weight class 15 down to j ($i < j$). The above test accurately bounds the breakpoint weight between weight classes i and j . In order to better represent a distinct point at which a carrier strategy should change, linear regression over the binding weight classes is used. Though the linear regression is expected to have a poor fit due to the variance of common carrier charges, a valuable breakpoint within the bounds can be predicted from the intersection of two lines of regression.

In order to provide a recommendation for the weight range that SSPAs should target for optimizing savings, the same method can be applied to the UPS discounted rates. The resulting breakpoint between strategies is the best maximum weight recommendation for future SSPAs until a more in depth analysis can be performed.

VI. RESULTS

A. LEAST EXPENSIVE CARRIER

The results of the first problem to determine the least expensive carrier using the Signed-Rank Test for a paired experiment are summarized in Table 3. below. The calculated Z statistic from the test is much greater than the z_{α} , which implies the H_0 is rejected and the H_a is accepted. Therefore, UPS is the least expensive carrier overall statistically with an $\alpha = 0.05$ when considering a weight range from 1 to 150 pounds.

$T^+ =$	61,289,094.5
$Z =$	57.492
$z_{\alpha} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis

Table 3. Wilcoxon Test Results

B. MOST BENEFICIAL WEIGHT RANGE TO USE UPS

1. Over-The-Counter Rates

The results of the 15 Wilcoxon Test to determine the bounding weight classes for O-T-C UPS rates are listed in Appendix B. Using an $\alpha = 0.05$, the first H_a is accepted for weight classes 1 through 10, the H_0 cannot be rejected for weight class 11, and the second

H_a is accepted for weight classes 12 through 15. It is clear that the breakpoint weight is bounded by weight classes 10 and 12.

Regression was performed over all members of classes 10, 11, and 12 (weight range of 91 to 120 pounds). The results are provided in Appendix B, predicting a breakpoint weight of 116 pounds. Therefore, the best weight range to use UPS for small parcel shipping would be from 1 to 116 pounds when using O-T-C rates. For all shipments greater than 116 pounds, common carriers are more affordable.

2. Discounted Rates

The results of the Wilcoxon Tests to determine the bounding weight classes for discounted UPS rates are listed in Appendix B. Only three tests were performed since the discounted UPS rates will always be at least as good as the O-T-C UPS rates. The first H_a is accepted for weight class 11. The H_0 cannot be rejected for weight class 12, and the second H_a is accepted for weight class 13. It is clear that the breakpoint weight to change the strategy from UPS to common carrier is bounded by weight classes 11 and 13.

Regression was performed over all members of classes 11, 12, and 13 (weight range of 101 to 130 pounds). The results are provided in Appendix B, predicting a breakpoint weight of 134 pounds. Since the purpose of the regression was to pick a breakpoint weight within the nonparametric analysis bounds, and the resulting weight is greater than the upper bound of 130 pounds; then the best weight range to use UPS for

small parcel shipping would be from 1 to 130 pounds when using SSPA discounted rates.

For all shipments greater than 130 pounds, common carriers are more affordable.

VII. CONCLUSIONS

A. INTERPRETATION OF RESULTS

SPCs are less expensive than the common carriers which are designed to carry much larger TL and LTL shipments. If the SPCs are utilized for all shipments of 150 pounds and under, and that qualify with respect to NMFC and dimensions, ITOs will most definitely save the DOD a significant amount on shipping charges. Table 4. summarizes potential savings with respect to the data and assumptions analyzed for both O-T-C and potential SSPA discounted rates. If the percent savings are applied to total dollars spent in FY 1993 [Ref. 2], the potential savings equates to 3.1 million dollars. ITOs need to be encouraged to use the SPCs to carry their small parcels in order to produce instant savings in shipping costs. However, blanket use of the SPCs is not the most cost effective way to employ them. The analysis shows that SPC rates for parcels approaching the upper weight limitations of the SPCs are more expensive than the common carriers currently being used. The intersection of two lines of regression shows that ITOs should use SPCs for all parcels 1 to 116 pounds, and optimal SSPA program agreements should target parcels 1 to 130 pounds. Table 5. and Table 6. summarize potential savings using the recommended strategy which is significantly better than using the SPCs for their entire weight range. If the percent savings are applied to total spent in FY 1993 [Ref. 2], the potential savings equates to between 3.4 and 3.8 million dollars.

Total Actual Cost	Total Over-The-Counter Cost	Total SSPA Cost
\$537,402.68	\$352,245.19	\$317,020.67
Percent Savings	34.45%	41.01%

Table 4. Potential Savings for 1 to 150 pounds SPC Employment

Total Actual Cost	Total Over-The-Counter Cost
\$415,090.25	\$215,436.34
Percent Savings	48.10%

Table 5. Potential Savings for Optimal SPC Employment

Total Actual Cost	Total SSPA Discounted Cost
\$466,857.63	\$242,756.81
Percent Savings	48.00%

Table 6. Potential Savings for Optimal SPC Employment

The SSPA program is on the correct path providing significant savings for those DLA depots involved. Agreements need to be tailored to only offer parcels 130 pounds or less to the SPCs, unless the SPCs can negotiate lower rates for the higher weight parcels. The typical ITO needs to be aware of the significant potential savings when SPCs are employed to carry their small parcels. Using 116 pounds to decide whether to use a SPC to carry their small parcels will provide additional savings to DOD transportation costs. However, the ITOs should be sensitive to the fact that the above breakpoint weight may vary significantly for their installation and they may need to alter their strategy accordingly.

B. FURTHER STUDIES RECOMMENDED

This thesis approached the problem of deciding if and how SPCs should be integrated into domestic traffic management from the macro level. Large level trend analysis has provided some basic guidelines for ITOs, and identified target weight ranges for SSPA program purposes to optimally reduce current DOD shipping costs. If more of a micro level analysis is performed for individual depots and installations, then even greater reduction of costs may be possible by optimally reducing each depot or installation shipping costs.

Evaluation of the SSPA program is recommended after the test DLA depots settle into the daily operation of the program. At that time specific agreement specification will be available as well as actual shipping data. A considerable amount of information can be determined from the analysis which may provide a better strategy for incorporating SSPA into the traffic management of additional depots and military installations.

APPENDIX A. FINS INQUIRY CODES

The following information was provided from the MTMC FINS Database Manager:

GENERAL PURPOSE INQUIRY

Legend:

ORIGIN	ORIGIN STATE
ORIGIN CITY	ORIGIN CITY
DEST ST	DESTINATION STATE
DEST CITY	DESTINATION CITY
ORIG GBLOC	ORIGIN POINT GOVERNMENT BILL OF LADING CODE
UFC/NMFC	UNIFORM FREIGHT CLASSIFICATION CODE OR NATIONAL MOTOR FREIGHT CLASSIFICATION NUMBER
CG	COMMODITY GROUP CODE
METH TRANS	METHOD OF TRANSPORTATION
ORIG CARR	ORIGIN CARRIER
PAYEE CODE	PAYEE CODE OF DELIVERING CARRIER
TOTAL WEIGHT	TOTAL WEIGHT OF SHIPMENT
TOTAL PAID CHARGES	TOTAL PAID CHARGES
DATE RECEIVED	DATE SHIPMENT IS PICKED UP BY CARRIER

DATE DELIVERED

DATE SHIPMENT IS DELIVERED BY
CARRIER

APP

APPROPRIATION CODE OF SERVICE,
PAYING TRANSPORTATION CHARGES

GBL

GOVERNMENT BILL OF LADING

VOUCHER

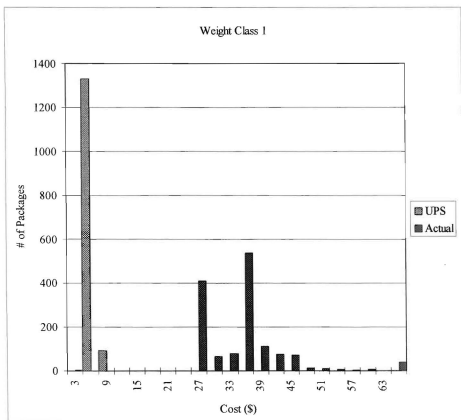
VOUCHER

APPENDIX B. RESULTING GRAPHS AND CALCULATIONS

Appendix B. contains graphs and calculations generated by the analyses performed in this thesis. They are provided to help the reader better comprehend the results provided in Chapter VI. The order of figures and tables is identical to the order they are referenced in Chapter VI.

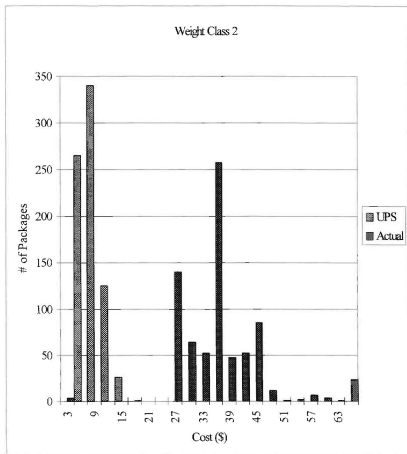
Weight Class 1

T^*	=	1,014,597
Z	=	32.686
z_{α}	=	1.645
p-value	=	0
Result	ACCEPT: First Alternative Hypothesis	



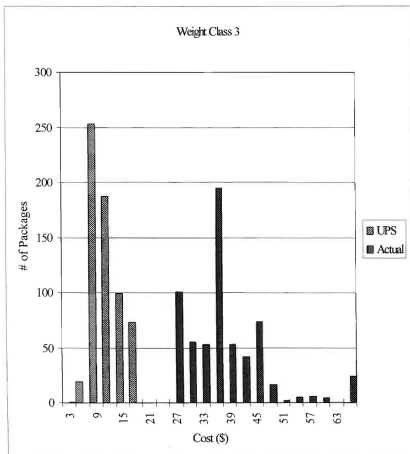
Weight Class 2

T'	286,897
Z	23.834
z_{α}	1.645
p-value	0
Result	ACCEPT: First Alternative Hypothesis



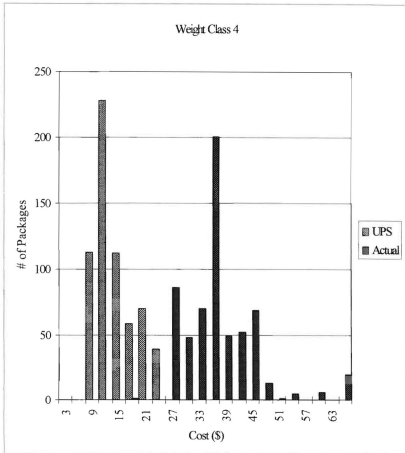
Weight Class 3

$T^* =$	199,395
$Z =$	21.763
$z_{\alpha} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis



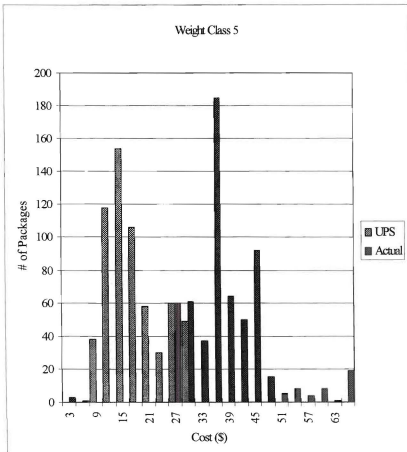
Weight Class 4

$T^* =$	193,131
$Z =$	21.590
$z_{\alpha} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis



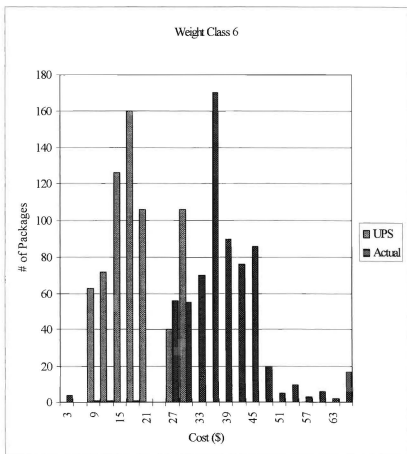
Weight Class 5

T^*	=	187,648
Z	=	21.572
$z_{\alpha^{**}}$	=	1.645
p-value	=	0
Result	ACCEPT: First Alternative Hypothesis	



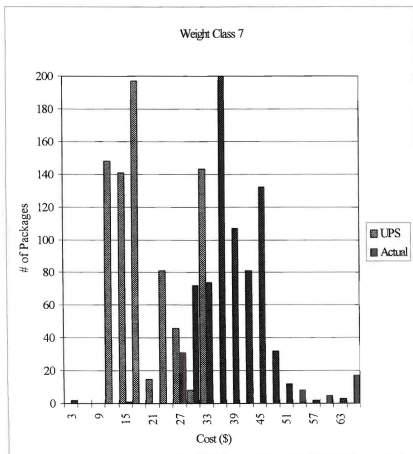
Weight Class 6

T^*	225,212
Z	22.160
z_{α}	1.645
p-value	0
Result	ACCEPT: First Alternative Hypothesis



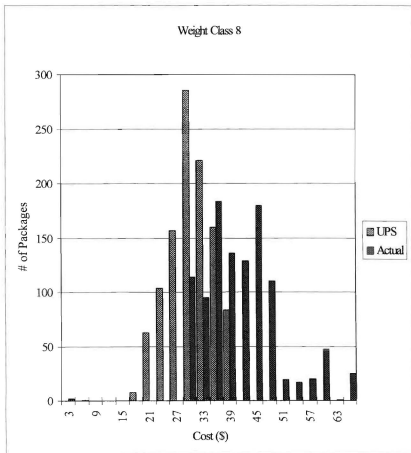
Weight Class 7

$T^* =$	303,027
$Z =$	24.054
$z_{\alpha^{**}} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis



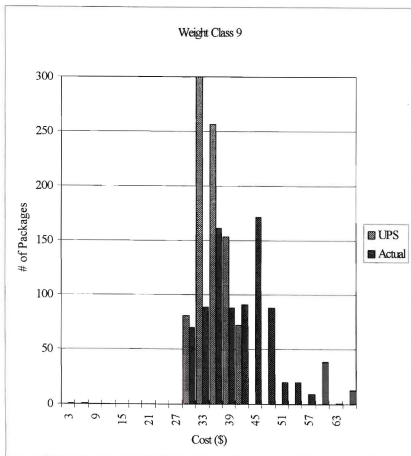
Weight Class 8

$T^* =$	571,423
$Z =$	26.995
$z_{\alpha} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis



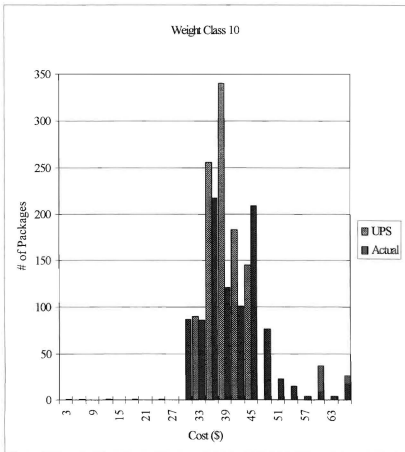
Weight Class 9

$T^* =$	323,306
$Z =$	18.781
$z_{\alpha} =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis



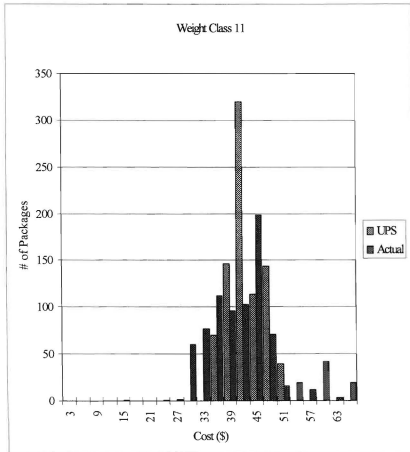
Weight Class 10

$T^* =$	336,844
$Z =$	8.796
$z_{\alpha} =$	1.645
p-value =	0
Result:	ACCEPT: First Alternative Hypothesis



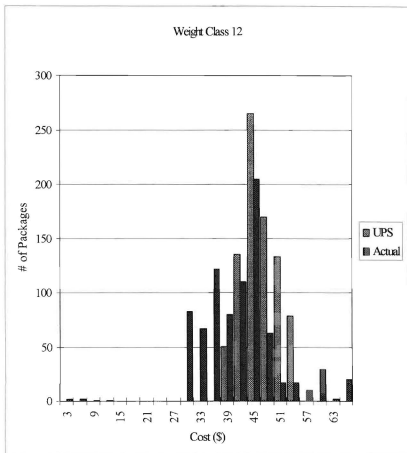
Weight Class 11

$T^* =$	170,593
$Z =$	-0.445
$z_{\alpha} =$	1.645
p-value =	0.672
Result	ACCEPT: Neither Alternative Hypothesis



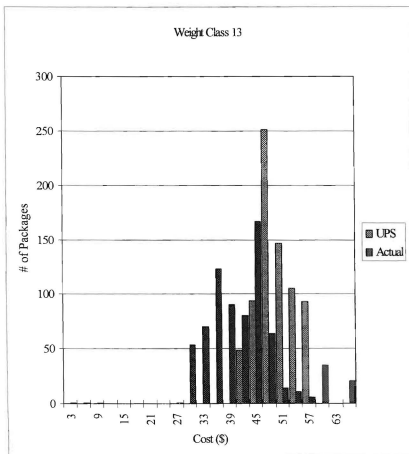
Weight Class 12

$T^+ =$	89,336
$Z =$	-12.142
$z_{\alpha} =$	1.645
p-value =	1
Result	ACCEPT: Second Alternative Hypothesis



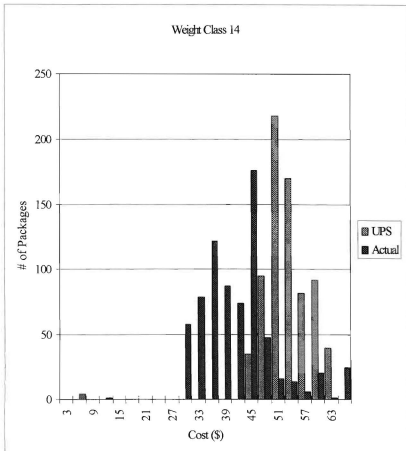
Weight Class 13

$T^* =$	40,870
$Z =$	-16.510
$z_{\alpha} =$	1.645
p-value =	1
Result	ACCEPT: Second Alternative Hypothesis



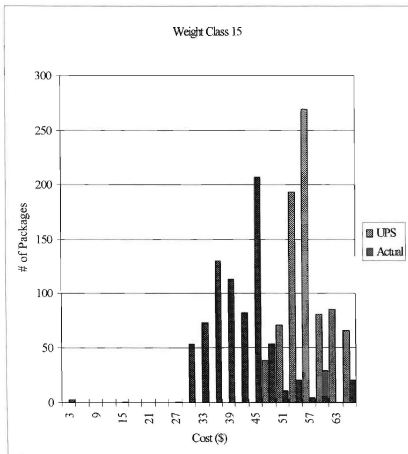
Weight Class 14

$T^+ =$	22,396
$Z =$	-19.525
$z_\alpha =$	1.645
p-value =	1
Result	ACCEPT: Second Alternative Hypothesis



Weight Class 15

$T^+ =$	16,228
$Z =$	-22.100
$z_{\alpha} =$	1.645
p-value =	1
Result	ACCEPT: Second Alternative Hypothesis



Discounted Weight Class 11

$T^+ =$	261,884
$Z =$	12.697
$z_\alpha =$	1.645
p-value =	0
Result	ACCEPT: First Alternative Hypothesis

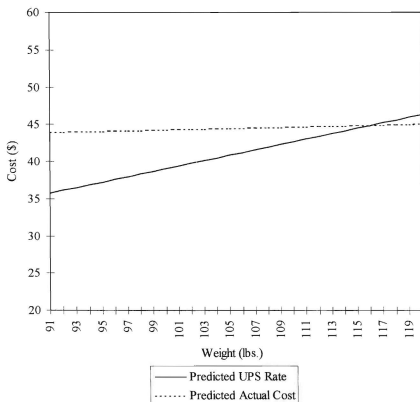
Discounted Weight Class 12

$T^+ =$	175,963
$Z =$	0.511
$z_\alpha =$	1.645
p-value =	0.305
Result	ACCEPT: Neither Alternative Hypothesis

Discounted Weight Class 13

$T^+ =$	89,275
$Z =$	-8.172
$z_\alpha =$	1.645
p-value =	1
Result	ACCEPT: Second Alternative Hypothesis

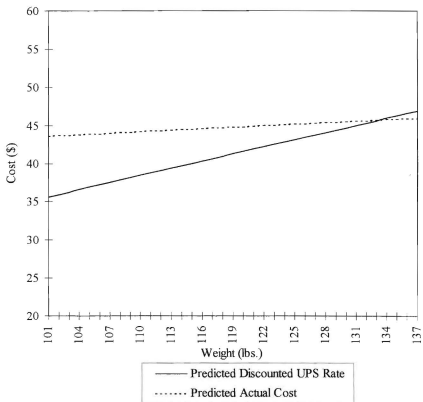
Over-The-Counter UPS Rate Breakpoint Regression Lines



UPS: Cost = 0.3633(Weight) + 2.6855 Actual: Cost = 0.0387(Weight) + 40.438

At Intersection: Weight = 116 lbs. with 80% Confidence Limit of [71, 194]

Discounted UPS Rate
Breakpoint Regression Lines



UPS: $\text{Cost} = 0.3137(\text{Weight}) + 3.9006$ Actual: $\text{Cost} = 0.0662(\text{Weight}) + 36.962$

At Intersection: Weight = 134 lbs. with 80% Confidence Limit of [75, 252]

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